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(56) Documents Cited
GB 1395260 A EP 0159834 A1 US 3861367 A

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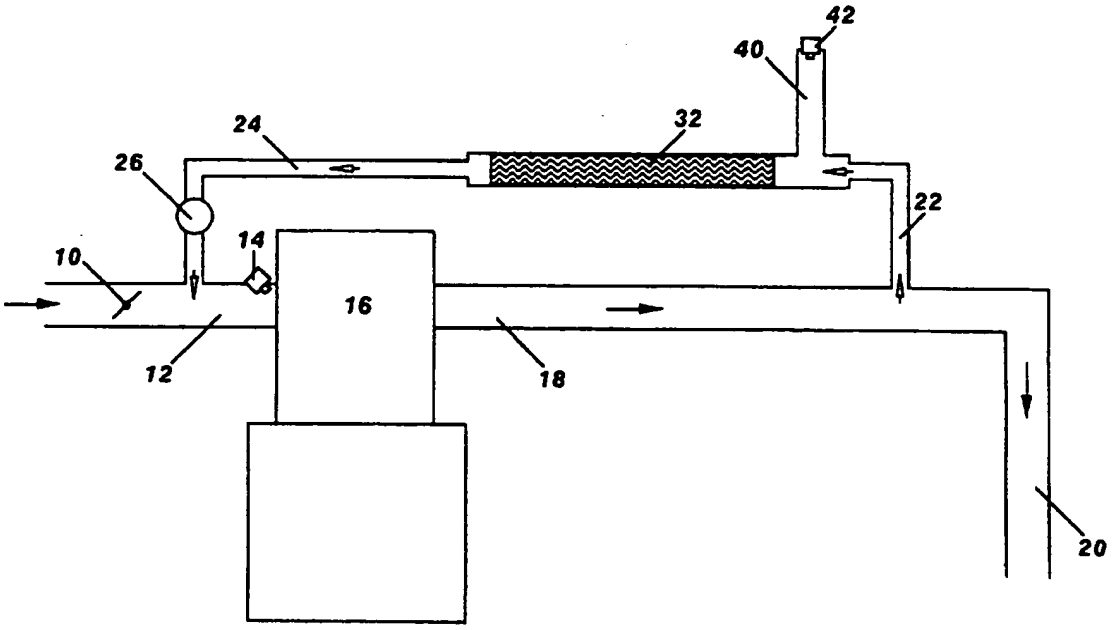
(54) I.c. engine EGR system has fuel injection, and catalyst to promote production of formaldehyde

(57) An i.c. engine 16 has an EGR pipe 22, 24 connected between exhaust system 18, 20 and intake 12. The engine is operated so that a surplus of oxygen is present in the recirculated exhaust gases. Fuel is injected at 42, 40 into the EGR pipe 22, to mix with the recirculated exhaust, and to partially react with the oxygen therein prior to entering the intake system. A catalyst 32 is fitted into the EGR pipe to promote the partial oxidation of the fuel. The catalytic material may be copper, gold, or silver, the latter two being coated onto a refractory capillary matrix substrate. The catalyst may be heated. A recirculation loop may be provided, including the catalyst, to lengthen the gas dwell time. A blower may be provided, which may be driven by the exhaust. Valve 26 controls the proportion of EGR.



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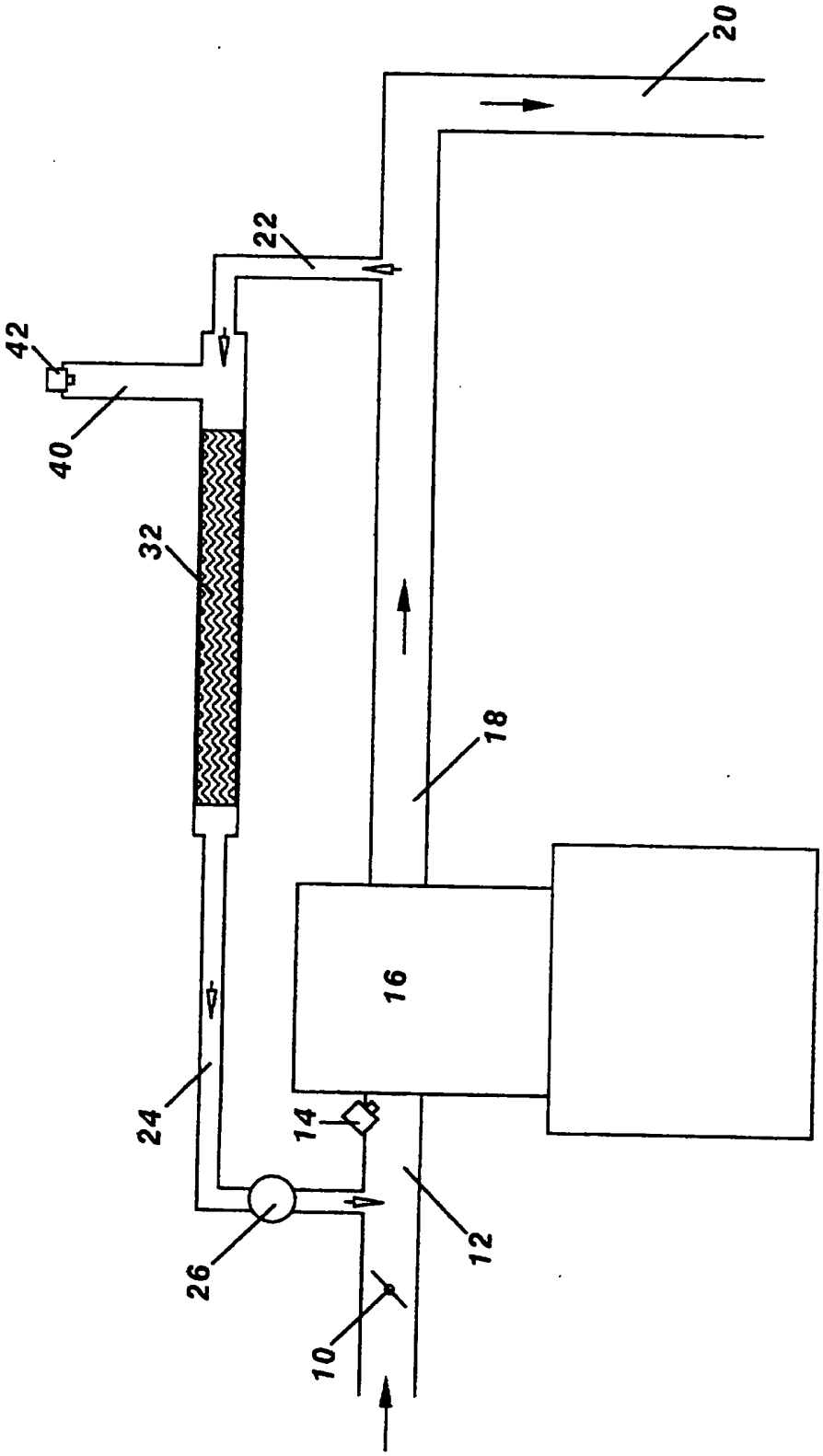
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Internal Combustion Engine

The present invention relates to an internal combustion engine having an exhaust gas recirculation (EGR) pipe connected between the exhaust system and the intake system of the engine, comprising means for ensuring that a surplus of oxygen is present in the recirculated exhaust gases and means for introducing fuel into the EGR pipe to mix with the recirculated exhaust gases and to be partially reacted with the oxygen in the recirculated exhaust gases prior to being returned to the engine intake system.

An engine as set out above has already been proposed in the Applicant's copending British Patent Applications 9613412.7, 9615768.0 and 9611468.1. In the latter applications, in order to ensure that the fuel injected into the EGR pipe reacts with the oxygen to form partial oxidation products, attention is paid to the dwell time of the EGR gases in the EGR pipe and the reaction temperature.

The present invention is characterised, on the other hand, by the provision of a catalyst in the EGR pipe for promoting partial oxidation of the fuel in the EGR pipe.

Surplus oxygen is present whenever an engine is operated in a lean burn mode but the invention is not restricted to lean burn engines as it is alternatively possible for an engine operating in a stoichiometric or rich mode to have a proportion of the metered air directed into the EGR pipe.

It has been found by experiment that the partial oxidation product that assists ignition of the mixture in the combustion chamber and thereby improves combustion stability is formaldehyde. Formaldehyde can be prepared by the oxidation of hydrocarbons in the presence of a catalyst such as copper, silver and gold and such a process is used

in the commercial production of formaldehyde. These metals therefore lend themselves well to use in a catalyst arranged in the EGR pipe of an internal combustion engine of the type described above.

The catalyst may comprise a substrate in the form of a refractory capillary matrix, such as used in exhaust catalytic converters, the catalyst metal being embedded in the surface of the substrate. This construction would be adopted when an expensive metal such as silver or gold is used as the catalyst. The use of a capillary matrix reduces the speed of the EGR gases and ensures that the gases remain in contact for a sufficient time with the catalytic material promoting the partial oxidation.

When copper is used as a catalyst, then it may be formed as a compacted mesh or as a sintered block through which the EGR gases flow.

It is possible, if desired to increase the dwell time by providing a circulation loop around the catalyst and if necessary the EGR gases may be driven around the loop by a blower, for example one connected to an exhaust gas turbine.

The invention will now be described further, by way of example, with reference to the accompanying drawing, in which the single figure is a schematic representation of an internal combustion engine of the invention.

The figure shows an engine 16 having an intake system that includes an intake manifold 12, a main intake throttle 10 and a fuel injector 14. The engine 16 has an exhaust system that comprises an exhaust manifold 18 and a downpipe 20. An EGR pipe 22, 24 connects the exhaust manifold 18 to the intake manifold 12, the proportion of exhaust gas recirculation being controlled by an EGR valve 26 arranged within the EGR pipe 22, 24.

The EGR pipe passes through a catalyst 32 and upstream of the catalyst 32 fuel is injected into the EGR gas flow by a fuel injector 42 connected into a branch 40.

The catalyst 32 can be a matrix coated with silver or gold or it may comprise a compacted mesh or a sintered block of copper. If desired the catalyst 32 can be heated.

The engine in the figure is a lean burn engine that receives a lean fuel to air mixture and therefore has surplus oxygen in its exhaust gases. If the engine is not a lean burn engine, then the presence of surplus oxygen in the EGR gases can be guaranteed by introducing part of the air metered to the combustion chambers directly into the EGR pipe. The purpose of the catalyst 32 in the EGR pipe is to promote partial oxidation of the fuel injected by the injector 42 in the surplus oxygen. The catalyst material, the temperature of the catalyst and the dwell time are selected to ensure that a substantial proportion of formaldehyde is produced amongst the partial oxidation products, this being known to improve the ignition stability of the engine.

The dwell time of the gases in the catalyst will depend on the flow resistance presented by the catalyst and can be increased by providing a circulation loop around the catalyst so that the EGR gases may pass more than once through the catalyst before being returned to the intake system. If desired, a blower can be arranged in the circulation loop to force the circulation. Such a blower can be driven by an engine exhaust gas turbine.

CLAIMS

1. An internal combustion engine having an exhaust gas recirculation (EGR) pipe connected between the exhaust system and the intake system of the engine, comprising means for ensuring that a surplus of oxygen is present in the recirculated exhaust gases and means for introducing fuel into the EGR pipe to mix with the recirculated exhaust gases and to be partially reacted with the oxygen in the recirculated exhaust gases prior to being returned to the engine intake system, characterised in that a catalyst is provided in the EGR pipe for promoting partial oxidation of the fuel in the EGR pipe.

2. An internal combustion engine as claimed in claim 1, wherein the engine is a lean burn engine to which the supplied fuel and air mixture is lean of stoichiometry, thereby ensuring that an excess of oxygen is present in the exhaust gases.

3. An internal combustion engine as claimed in claim 1 or 2, wherein means are provided for introducing an additional metered quantity of air into the EGR pipe to mix with the recirculated exhaust gases.

4. An internal combustion engine as claimed any preceding claim, wherein the catalyst and the physical conditions prevailing in the EGR pipe are such that a significant quantity of formaldehyde is formed by the partial oxidation of the fuel.

5. An internal combustion engine as claimed in claim 4, wherein the material of the catalyst is selected from the group of metals comprising copper, silver and gold.

6. An internal combustion engine as claimed in any preceding claim, wherein the catalyst comprises a substrate

in the form of a refractory capillary matrix, the catalyst metal being embedded in the surface of the substrate.

7. An internal combustion engine as claimed in any one of claims 1 to 5, wherein the catalyst is formed as a compacted mesh or as a sintered block through which the EGR gases flow.

8. An internal combustion engine as claimed in any preceding claim, wherein a circulation loop is provided around the catalyst to recycle the EGR gases and thereby increase the dwell time of the gases in proximity to the catalyst.

9. An internal combustion engine as claimed in claim 8, wherein a blower is arranged within the circulation loop to provide forced circulation of the EGR gases over the catalyst.

10. An internal combustion engine as claimed in claim 9, wherein the blower is driven by an engine exhaust gas turbine.

11. An internal combustion engine as claimed in any preceding claim, further comprising means for heating the catalyst.

12. An internal combustion engine constructed arranged and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

The Patent Office

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Application No: GB 9625461.0
Claims searched: All

Examiner: Ken Strachan
Date of search: 3 March 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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F02M: 25/07, 25/14, 27/02, 31/08, 31/18, 33/00;

Other: Online database: WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 1,395,260	(Siemens) See figure 1; notice catalyst 5 for cracking of fuel, ignition device 7 for heating catalyst.	1, 11, at least
Y	EP 0,159,834A1	(Jaguar) See figure 1; notice cracking of fuel within combustion chamber 1c, EGR system 5, 8.	1, 11, at least
Y	US 3,861,367	(Kelmar) See figures 1 and 2; notice EGR via pump 32, oxygen feed from tanks 20.	1, 11, at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.